



Atomic Energy
Control Board

P.O. Box 1046
Ottawa, Canada
K1P 5S9

Commission de contrôle
de l'énergie atomique

C.P. 1046
Ottawa, Canada
K1P 5S9

**AECB STAFF ANNUAL REPORT OF
PICKERING NGS
FOR THE YEAR 1990**

August 1991

Canada

Report

TABLE OF CONTENTS

	<u>PAGE</u>
1. INTRODUCTION	1
2. STATION OPERATION - PICKERING NGS-A AND -B	1
3. REVIEW OF OPERATIONAL SAFETY ASPECTS	3
3.1 Operation Common to Pickering NGS-A and Pickering NGS-B	3
3.1.1 Station Compliance with Operating Licences	3
3.1.2 Quarterly Reports	3
3.1.3 Radiation Protection	3
3.1.4 Station Effluents and Environmental Monitoring	5
3.1.5 Audits and Appraisals	8
3.1.6 Training	8
3.1.7 Emergency Exercises and Drills	9
3.1.8 Security	9
3.1.9 Station Maintenance	10
3.1.10 Station Management	11
3.1.11 Housekeeping	12
3.1.12 AECB Staff Inspections	13
3.1.13 Quality Improvement Program (QIP)	13
3.1.14 Safeguards	14
3.2 Pickering NGS-A	14
3.2.1 Process Systems	14
3.2.2 Chemistry	14
3.2.3 Performance of Special Safety Systems	15
3.2.4 Reportable Significant Events	18
3.2.5 Measures of Station Performance	18
3.3 Pickering NGS-B	18
3.3.1 Process Systems	18
3.3.2 Chemistry	18
3.3.3 Performance of Special Safety Systems	18
3.3.4 Reportable Significant Events	19
3.3.5 Measures of Station Performance	19

	<u>PAGE</u>
4. SIGNIFICANT LICENSING MATTERS AND ACTIVITIES	20
4.1 Common to Pickering NGS-A and Pickering NGS-B	20
4.1.1 Emergency Response Capability	20
4.1.2 Vacuum Building and PRD Inspection Outage	21
4.1.3 Boiler Emergency Cooling System (BECS) Status	22
4.1.4 Environmental Qualification (EQ)	22
4.1.5 Filtered Air Discharge System (FADS)	23
4.1.6 Post-Accident Radiation Monitoring	23
4.1.7 Steam Line Failures Outside Reactor Building	23
4.2 Pickering NGS-A	24
4.2.1 Loss of Coolant Accident (LOCA) and Failure to Shut Down	24
4.2.2 Rupture Panel System (RPS)	25
4.2.3 Unit 2 Flux Tilt Event	25
4.2.4 Calandria Vault Corrosion	26
4.3 Pickering NGS-B	26
4.3.1 Mercury-Wetted Relays	26
4.3.2 Moderator Low Level Trip	27
5. CONCLUSION	27
TABLE 1 Ontario Hydro Definitions of Some Fault Types and Levels of Impairment	
TABLE 2 Failures of Mercury-Wetted Relays in Pickering NGS-B Special Safety Systems	
APPENDIX A Measures of Station Performance Pickering NGS-A, 1990	
APPENDIX B Measures of Station Performance Pickering NGS-B, 1990	
APPENDIX C Reportable Events	
APPENDIX D Violations of Licences and Regulations	

1. INTRODUCTION

The operation of Pickering NGS-A Units 1-4 and Pickering NGS-B Units 5-8 is monitored to ensure compliance with licensing and safety requirements by the AECB Pickering project office staff in cooperation with AECB staff in Ottawa.

This report presents AECB staff's review of licensing issues and of the operational performance of Pickering NGS during 1990. More detailed information on performance is contained in Ontario Hydro's 1990 Quarterly Technical Reports for Pickering NGS-A and Pickering NGS-B.

2. STATION OPERATION - PICKERING NGS-A AND -B

During 1990, the following capacity factors were achieved:

Unit 1:	67%	Unit 5:	86%
Unit 2:	65%	Unit 6:	77%
Unit 3:	0%	Unit 7:	77%
Unit 4:	23%	Unit 8:	66%

For Pickering NGS-A, the station net capacity factor for 1990 was 39% compared to the overall lifetime capacity factor of 67%.

For Pickering NGS-B, the station net capacity factor for 1990 was 76% compared to the overall lifetime capacity factor of 84%.

A planned vacuum building outage (required every ten years) commenced on May 4, 1990. The outage required the negative pressure containment system to be out of service for a period of 24 days during which time all eight Pickering NGS units were shut down. Major work performed during the outage included work on the pressure relief duct, replacement of the vacuum building roof seal and an overhaul of the pressure relief valves which isolate the atmosphere of the pressure relief duct from that of the vacuum building during normal operation (see Section 4.1.2)

Unit 3 was out of service for the entirety of 1990 on a 23-month scheduled retube and rehabilitation outage which began on June 3, 1989. Fuel channel replacement and a significant amount of rehabilitation work were completed by December, 1990. Rehabilitation work encompassed a number of improvements to safety systems, such as installation of a high pressure emergency core cooling system (ECCS), conversion of ten adjusters to shut-off rods, installation of a new rupture panel system (RPS) in containment and improvements to the control room annunciation system. Significant accomplishments during the outage include:

- a) Total carbon-14 dose of 0.01 person · Sv and no incidents of spread of carbon-14 contamination outside the reactor vaults or of contamination of any workers.
- b) No unplanned exposures of retube/rehabilitation staff.

- c) Use of information systems to achieve a high level of control of administrative procedures and processes, and control of work in the field.
- d) Good procedural compliance and low frequency of maintenance rework.
- e) Demonstrated the benefits of a new organizational approach for Unit 3 retube/rehabilitation versus Units 1 and 2. On Unit 3, a separate integrated project management team was established to look after the outage. The outage length of Unit 3 is predicted to be about half that of the other units.
- f) A major improvement in the housekeeping and material condition of the unit.

Approval to load tritiated heavy water into the moderator system was granted in December, 1990. Fuel loading was approved in January, 1991. First criticality was achieved in May, 1991.

Unit 4 was shut down on April 27, 1990, before the vacuum building outage, and remained shut down for a comprehensive fuel channel inspection and maintenance program until December 30, 1990. The inspection and maintenance program, which included the removal and replacement of three pressure tubes, was designed to demonstrate fitness for continued service of the pressure tubes for at least another full year of operation. Following an exhaustive assessment of the results of the inspection and maintenance program, AECB staff approved the restart of the unit in December, 1990, for full power operation until August 15, 1991, at which time the unit will be shut down for retube.

A program for demonstrating the concept of above-ground dry storage of spent fuel continued at Pickering NGS during 1990. The demonstration consists of the outdoor storage of two concrete integrated containers (CIC), each loaded with 384 bundles of spent fuel. The CICs are monitored regularly for radiation levels, surface contamination and seal integrity. No unusual results were recorded during the year. The demonstration period for the older CIC longest in storage will be terminated in late 1991, at which time the fuel will be returned to the auxiliary irradiated fuel bay (AIFB). The fuel in the second CIC will also be returned eventually to the AIFB.

A new meteorological monitoring system was installed and was being tested in 1990 at Pickering NGS. The system consists of a 50-metre instrumented tower and a 10-metre mast, situated within the exclusion boundary north of the station. Wind speed, wind direction, and temperature data will be collected and transmitted to the Pickering NGS-A and -B control rooms and to the emergency response centre. The new system will obtain meteorological data which are more representative of the conditions at site than the old system.

3. REVIEW OF OPERATIONAL SAFETY ASPECTS

3.1 Operation Common to Pickering NGS-A and Pickering NGS-B

3.1.1 Station Compliance with Operating Licences

In 1990, both Pickering NGS-A and -B licences were renewed for a period of one year, effective October 1, 1990.

During 1990, there were nine infractions of the operating licences, of which six were non-compliances with the Operating Policies and Principles (OP&Ps) and one was a non-compliance with the Ontario Hydro Radiation Protection Regulations. In addition, there were four violations of the Atomic Energy Control (AEC) Regulations and there was one violation of the Physical Security Regulations. These are listed in Appendix D.

The total number of infractions (including violations) has decreased compared to 1989 (see Figure 1, next page), and the trend throughout 1990 has been to a lower frequency of infractions (most of the infractions occurred in the first half of the year). Ontario Hydro has continued efforts in 1990 toward better compliance with the licences and regulations through several activities including root cause evaluation of events and additional training on OP&Ps. AECB staff is of the view that further improvement in this area is needed.

During 1990, reporting of events pursuant to licence conditions was not always prompt and for some events there was no formal reporting until requested by AECB staff. Compliance difficulties in this area are due in part to the broad nature of the reporting requirements leading to differences in interpretation, and also failure by Ontario Hydro staff to recognize some events as reportable. Actions underway by Ontario Hydro and AECB staff should result in improved compliance in this area.

3.1.2 Quarterly Reports

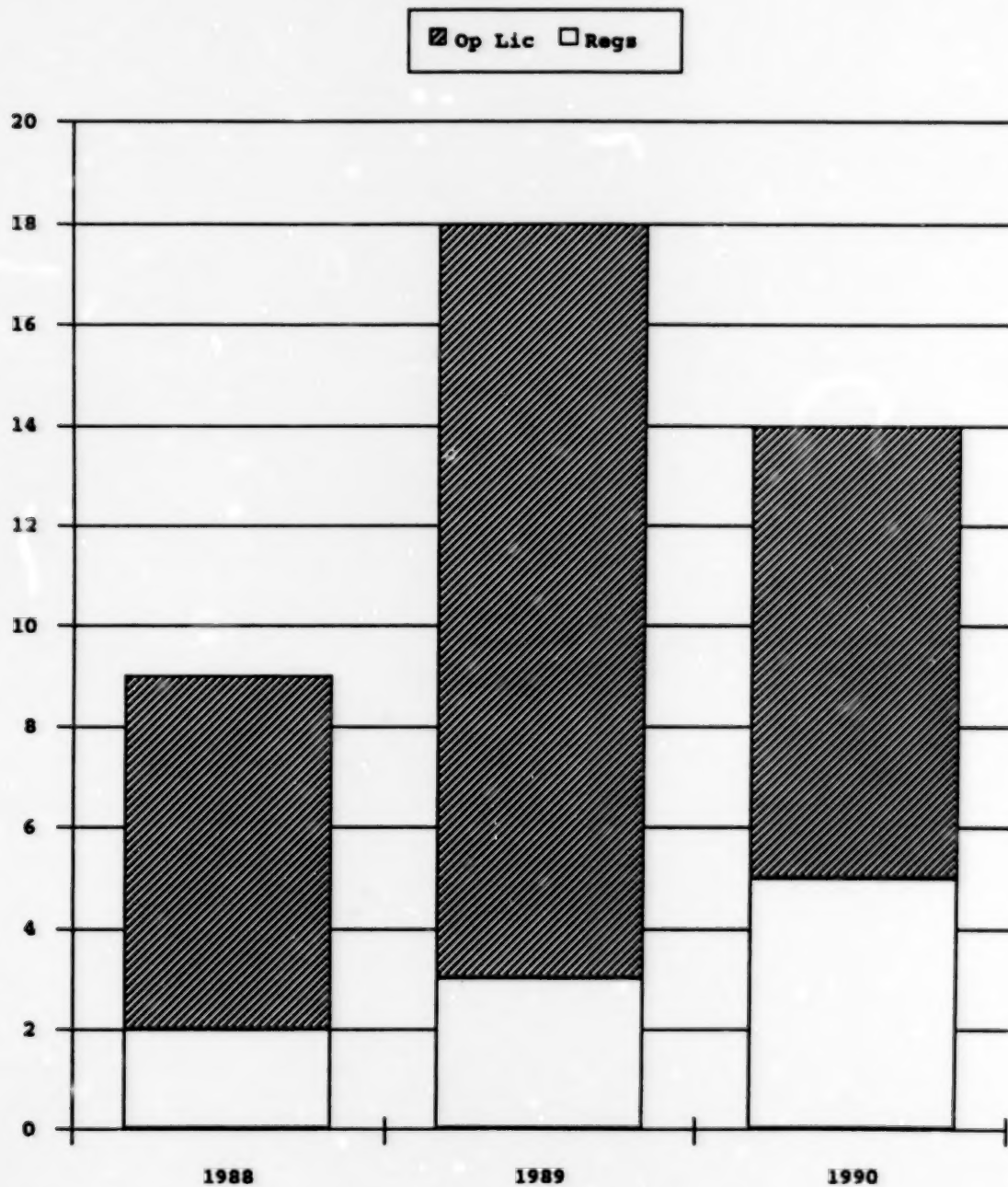
Ontario Hydro submits technical reports on a quarterly basis, which together summarize station operation for the year. During 1990, these were submitted in a timely manner. The reports have been reviewed by the AECB staff and, in general, were found to reflect accurately station operation for 1990. AECB staff comments on specific topics are given in the following sections of this report.

3.1.3 Radiation Protection

Last year, AECB staff reported on the exposure of three workers to radiation doses in excess of the regulatory limits while removing an irradiated cobalt adjuster rod from Unit 1. As a result of these overexposures, charges were laid against Ontario Hydro under the AEC Act. On August 2, 1990, Ontario Hydro pleaded guilty to four of the five charges; the fifth charge was withdrawn. The charges were:

Figure 1

**Pickering NGS - Violations of Regulations &
Operating Licences**



- a) One count of failure to take reasonable precautions in relation to the nuclear facility to protect persons from injury.
- b) Three counts of exposing employees to doses of ionizing radiation in excess of the doses specified in Schedule II of the AEC Regulations.
- c) One count of not operating in accordance with the licence (this count was withdrawn).

Ontario Hydro was fined \$4,500 per count for a total of \$18,000.

This is the first time in the history of Ontario Hydro's nuclear program that the utility has been prosecuted under the AEC Act and Regulations.

Following Ontario Hydro's investigation into the adjuster rod radiation overexposure incident, a program of 27 actions was undertaken to address the investigation report findings. Seven actions remain outstanding. These are scheduled for completion by the end of 1991.

In June, 1990, two AECB staff assessment reports addressing the overexposure event were forwarded to Ontario Hydro. Ontario Hydro was requested to submit an action plan and schedule for addressing the recommendations in the reports. A reply has been received which indicates that all recommendations, except for one, will be addressed by the end of 1991. The exception is a recommendation which states that a system for controlling movable shielding equipment should be instituted. Short-term actions are complete, but longer-term solutions include the addition of new facilities. The target completion date for full implementation is 1994.

During 1990 no individuals received doses exceeding the regulatory dose limits.

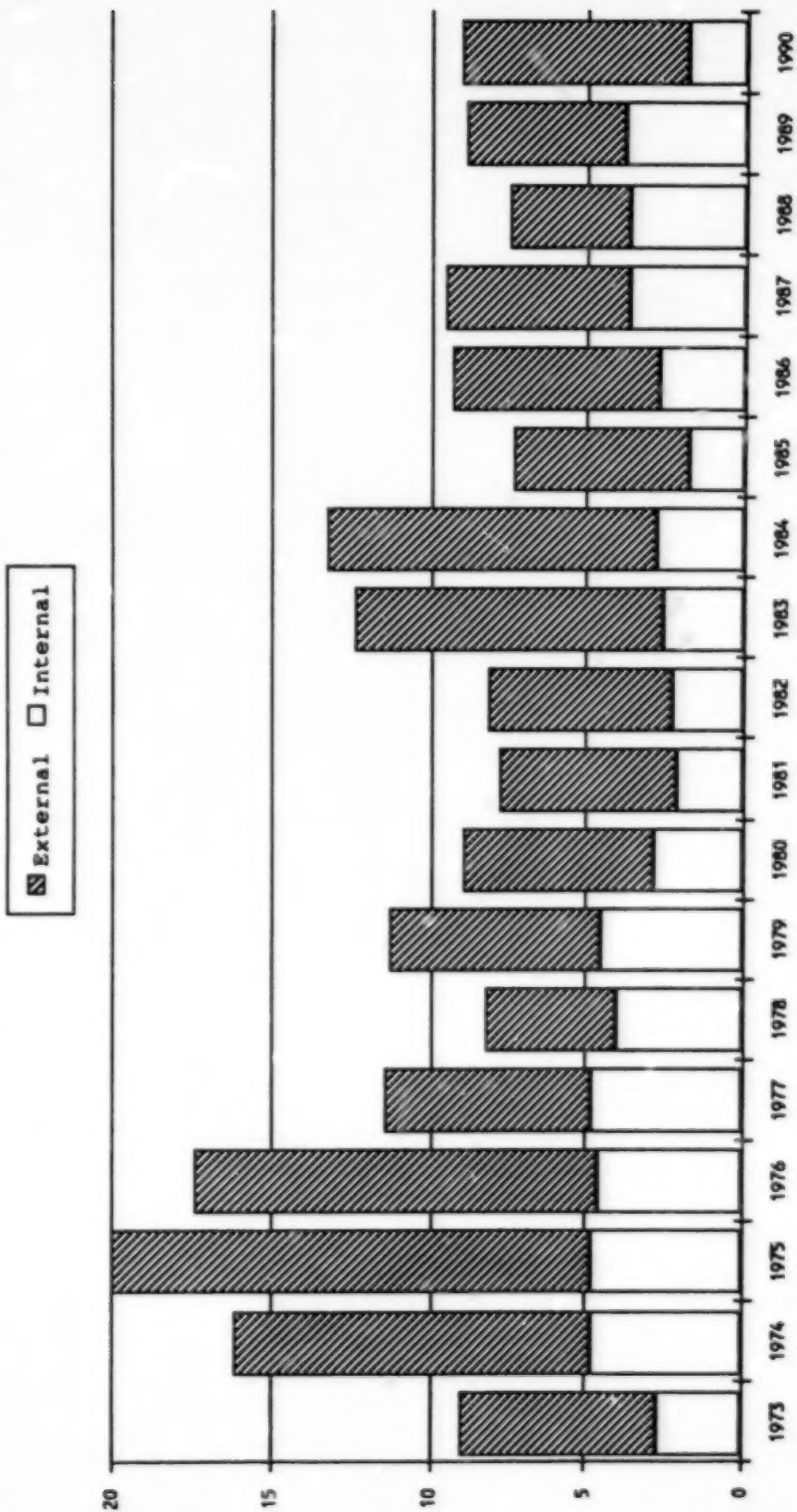
Total whole body doses for all workers at Pickering NGS for 1990 was 9.01 person · Sv, compared to the previous year's total of 8.89 person · Sv. The increase from 1989 is attributed to the retube activities on Unit 3.

Table 3.1.3.1 at the end of this section presents a summary of Pickering NGS-A, Pickering NGS-B and the combined total whole body dose distribution for the equivalent calendar year (ECY) period ending in 1990.

Figure 2 next page, shows a history of collective whole body dose for the station since 1973. It should be noted that the Pickering NGS-A units went in service during the period 1971-73 and the Pickering NGS-B units went in service during the period 1983-86. As can be seen from Figure 2, for 1990, a significant reduction in the internal dose occurred. This is due, in part, to the processing of Pickering NGS heavy water by the Darlington Tritium Removal Facility which has, to date, resulted in a reduction of the tritium inventory at Pickering NGS by about 50%. Clearly, the detritiation program and other initiatives undertaken by Ontario Hydro have made a positive contribution toward the reduction of personnel dose. However, until Unit 4 retube has been completed, collective whole body dose is not expected to drop significantly at the station.

Figure 2

Pickering NGS: Collective Whole Body Dose (Sieverts)



The new Ontario Hydro Radiation Protection Regulations came into effect on June 1, 1990. Implementation of procedural and equipment changes to comply with the requirements of the new regulations were continuing at year end.

Table 3.1.3.1

Summary of Whole Body Dose Distribution for ECY
Period Ending in 1990

Dose in mSv	Number of Individuals		
	Pickering NGS-A*	Pickering NGS-B	Total
No dose assigned	959	60	1019
< 5	1453	401	1854
> 5 to 10	269	62	331
> 10 to 15	121	7	128
> 15 to 20	73	-	73
> 20 to 25	43	-	43
> 25 to 50	1	-	1
> 50	1**	-	1

* Doses for those working on both stations are reported under Pickering NGS-A.

** Related to August 2, 1989, overexposure. The workers' ECY for dosimetry purposes ended in 1990.

3.1.4 Station Effluents and Environmental Monitoring

3.1.4.1 Station Effluents

No events leading to large unplanned emissions of radioactive material occurred during 1990.

On one occasion during 1990, airborne noble gas releases slightly exceeded 1% of the weekly emission limit for Pickering NGS-A. This was due to leakage of air into the Unit 4 annulus gas system and the subsequent production and release of argon-41, a radioactive noble gas. Except for this event, the gaseous emissions via monitored pathways for tritium, iodine-131, particulates, noble gases and carbon-14 were all less than 1% of the Derived Emission Limits (DEL) for each group. Table 3.1.4.1 gives the annual average gaseous emissions via monitored pathways.

Table 3.1.4.1

Gaseous Emission (% of DEL)

Radionuclide Group	H-3	I-131	Particulates	Noble Gas	C-14
Pickering NGS-A Annual Average	0.23	0.01	< 0.01	0.37	0.11
Pickering NGS-B Annual Average	0.10	<0.01	<0.01	0.22	-

The liquid effluent emissions for tritium and for gross beta-gamma were also less than 1% of the DELs. Table 3.1.4.2 gives the annual average liquid emissions via monitored pathways.

Table 3.1.4.2

Liquid Emission (% of DEL)

Radionuclide Group	Tritium	Gross Beta-Gamma
Pickering NGS-A Annual Average	0.06	0.15
Pickering NGS-B Annual Average	<0.01	0.02

Last year AECB staff reported on interruptions of effluent monitoring, and that Ontario Hydro was asked to clarify how compliance with condition A.A.7 of the Pickering NGS-A and -B operating licences is assured (which stipulate that the rate of release of prescribed substances shall be monitored), and what would be considered a reportable event for compliance monitoring. Ontario Hydro has replied to the request but has not addressed the issues to the satisfaction of the AECB staff. Additional information has been requested.

Table 3.1.4.3 shows the number of effluent monitoring interruptions, and the total number of hours the effluent monitors were unavailable at Pickering NGS during 1990. The total number of liquid effluent monitoring interruptions increased compared to 1989.

Ontario Hydro has undertaken a program to improve the reliability of effluent monitoring at Pickering NGS. Installation of new equipment has started and a decrease in compliance monitoring interruptions is expected in 1991.

Table 3.1.4.3

Number of Monitoring Interruptions in 1990

	Number of Monitoring Interruptions and Number of Hours(h) Interrupted			
	Pickering NGS A	Pickering NGS B	Common Location	Total
Liquid Monitoring*	4 341 h	14 251.4 h	18 369.6 h	36 962 h
Gaseous Monitoring	4 106.2 h	3 43 h	5 54.3 h	12 203.5 h

* Excluding interruptions associated with normal weekly sampling.

3.1.4.2 Environmental Monitoring

Environmental surveillance data in the vicinity of Pickering NGS are collected routinely by Ontario Hydro and analyzed to determine the levels of radioactive materials in the environment due to the operation of the station, and to assess the radiation dose to the public from such operation. Parameters measured are tritium-in-air, tritium-in-precipitation, gross beta in precipitation, tritium and gross beta in drinking water and external gamma exposure. Monitoring for tritium, iodine-131 and carbon-14 in milk is done by analyzing samples collected monthly from a Pickering NGS area dairy farm.

During 1990, tritium was detected in concentrations statistically greater than background in air, precipitation, drinking water, milk and local produce. Carbon-14 was also detected above background levels in food, vegetation and in milk from the surrounding area.

3.1.4.3 Population Dose

The resulting dose to a member of the critical group, a six-month old infant, was assessed to be 44.5 μ Sv (micro-Sieverts) and 35.3 μ Sv for the International Commission on Radiological Protection (ICRP) reference man. They are 0.89% and 0.71% of the regulatory limit, respectively. The population dose from all emissions was assessed to be 1.45 person $\cdot$ Sv. The comparatively high value of population collective dose is a reflection mainly of the large population in the vicinity of the station.

3.1.4.4 Dry Storage Modules (DSM) and Storage Area Monitoring

At the end of 1990, the contact gamma dose rate of six DSMs exceeded the action level of 25 $\mu\text{Sv/h}$. In all cases, signs were posted. Loose contamination, yard drainage beta-gamma activity and perimeter fence gamma dose rates were all less than their respective action levels of 50 cpm/100 cm^2 , 140 $\times 10^{-7}$ kBq, and 2.5 $\mu\text{Sv/h}$.

3.1.5 Audits and Appraisals

A quality assurance survey was carried out in October, 1990, to review Ontario Hydro's construction and operations cleanliness program for the retube and rehabilitation of Unit 3. AECB staff concluded that Ontario Hydro's program appeared to be generally sound and a more detailed audit was scheduled for 1991.

A pre-audit review of maintenance activities at Pickering NGS was carried out in November, 1990, by AECB staff, in preparation for a planned audit of the maintenance program early in 1991.

A comprehensive internal audit, referred to as a "peer evaluation", was carried out by Ontario Hydro at Pickering NGS in November, 1990. Although the performance of the station in a number of areas was considered to be commendable, performance in others was found in need of improvement. Areas for improvement include system chemistry control, the storage of chemicals and waste oil, cleanliness, mechanical maintenance practices, work planning, the quality of radiation protection training, the planning of radioactive work and the availability of radiation instruments. The effectiveness of corrective action initiated by Pickering NGS will continue to be monitored by AECB staff.

At year end, a number of actions from AECB quality assurance audits and health physics appraisals of previous years remain outstanding. However, AECB staff believes that sufficient effort and appropriate priority are being applied to the work underway to complete such actions. AECB staff will continue to monitor progress.

3.1.6 Training

The success rate achieved at Pickering NGS on the AECB "General" examinations for control room operators and shift supervisors for both plants was 22 out of 23 candidates (96%). This compares with the average success rate of 94% for all Canadian plants for the year.

For the "Specific" examinations the results were five successful candidates out of five (100%) for Pickering NGS-A, and nine out of 12 (75%) for Pickering NGS-B. The average success rate for all plants in this category was 82%.

The evaluation component of the simulator-based refresher training program for control room operators and shift supervisors was discontinued by Ontario Hydro in 1989 and remained unavailable throughout 1990. Changes in the

assessment process (to include team evaluation) and improvement in relevant station operating procedures were accomplished and "dry-run" implementation of the revised approach is planned for early 1991.

3.1.7 Emergency Exercises and Drills

3.1.7.1 Radiation Emergency Practices

All schedule shift crew practices were held in 1990. The total for 1990 was 31 crew drills compared to 20 in 1989.

3.1.7.2 Seismic Emergency Practices

Each shift crew on Pickering NGS-B held its two scheduled seismic emergency practices for 1990. This is a big improvement from 1989 when only one shift crew held a practice due to an oversight in planning and scheduling.

3.1.7.3 Station Radiation Emergency Exercises

The annual station radiation emergency exercise was held on November 3, 1990. The Pickering project office staff together with two officers from the Operator Certification Division evaluated the exercise. In particular, station performance in eleven of the twelve areas where recommendations for improvement were given in the 1989 Pickering NGS emergency drill corporate evaluation report, were assessed. Minimal improvement was found in all eleven. An assessment report which details the findings and comments of the AECB staff evaluation has been forwarded to Ontario Hydro.

3.1.7.4 Fire Exercises

In response to AECB staff comments on the station's firefighting capabilities, station management confirmed in 1990 that Ontario Hydro's Nuclear Generation Division (NGD) policy on fire prevention and protection for nuclear generating stations will be applied at Pickering NGS. Ontario Hydro has submitted to the Pickering project office its strategy for full implementation of the policy by December 31, 1991. Among other actions, it calls for a full-time fire and rescue coordinator who will, acting on behalf of the Operations Superintendent, have overall responsibility and accountability for station fire safety. AECB staff views this as an important and necessary step toward improved coordination of fire fighting capability at Pickering NGS.

There was one joint Pickering NGS-Pickering Fire Department fire drill held in June, 1990.

3.1.8 Security

The station's basic security systems remain in a transitional status as a result of the replacement of the protected area barrier (fence), associated lighting and closed circuit television surveillance and assessment systems, as well as an extensive overhaul of the security monitoring room. Although predicts that the project will be completed on schedule (December, 1991).

The security guard establishment experienced a substantial personnel shortage during much of 1990 (ranging from 20-25%) which resulted in a noticeable reduction in routine patrols and other activities. This problem was rectified late in the year.

Regular individual security shift crew exercises were conducted throughout 1990. However, due to personnel shortages and other difficulties no major security exercise was carried out. Ontario Hydro intends to carry out a major exercise involving the Durham Regional Police in 1991.

3.1.9 Station Maintenance

3.1.9.1 Maintenance

Last year AECB staff reported on the progress being made in the area of maintenance of fuel handling systems. In spite of improvements, the Pickering NGS-B units continued to suffer from lack of refuelling during 1989 to the extent that the reactors were operated frequently with adjuster rods withdrawn. During 1990, improved fuel handling operator availability and further maintenance initiatives resulted in the achievement of a refuelling rate such that early in 1991 there were no reactors operating with adjusters withdrawn due to lack of refuelling.

Overall, station maintenance performance in 1990 did not improve significantly over the previous year. There was still excessive effort on breakdown rather than preventative maintenance, while a large backlog of work, significant rework, and lack of procedural compliance continued. Ontario Hydro efforts during 1990 focused on clearly identifying the maintenance areas requiring improvement, developing approaches for improvement, and putting into place a maintenance indicator monitoring program.

A maintenance engineering group was established to give additional support for maintenance activities; however, its role is not yet fully developed nor is the section sufficiently staffed. An NGD policy on maintenance was issued during the period and efforts for compliance have been initiated.

Efforts underway to improve maintenance include:

- Acquiring and training of additional staff, and reducing the backlog of training of existing staff. By the mid-1990's, 85% of the staff is expected to be at a fully qualified level.
- Increasing the 'time on the job' (wrench time) per shift.
- Identifying areas prone to rework and alerting workers to the need for extra care and performing root cause analysis to identify changes which would reduce the likelihood for rework.
- Revising out-of-date procedures.
- Instituting a procedural compliance audit program.

Some improvement in maintenance performance became evident during the first quarter of 1991 but significant turnaround is not expected until 1992. AECB staff considers that the current drive toward improvement will need to be

fully developed and maintained for some time in order to achieve a fully satisfactory standard of maintenance at Pickering NGS.

3.1.9.2 Surveillance of Systems

Pickering NGS has in place a surveillance program designed to satisfy several objectives, two of which are:

- to ensure the station is operated and maintained in a manner which is consistent with the operating licences, OP&Ps, and associated licensing documents.
- to ensure the system performance is routinely monitored and, where necessary, tested in a systematic fashion such that trends toward degradation of performance and documentation are identified early and corrective actions are taken.

AECB staff views this surveillance as an important aspect of station operation to give added assurance of station compliance with the conditions of the operating licences.

Last year AECB staff reported that surveillance of systems by the Technical Section had deteriorated to the point where it was clearly less than adequate to meet the stated objectives.

During 1990, training of new staff continued and additional staff was hired. A number of initiatives were undertaken in the area of technical support and surveillance, including the improvement of reactor safety awareness, improvement of work review processes, and increased presence in the field. However, the implementation of the Technical Section's system surveillance program has been slowed at the section level, primarily because of limited experience and training of the staff, and difficulties integrating a new process with existing practices. Full implementation is not expected before the end of 1992.

Ontario Hydro has expended significant effort to improve the effectiveness and performance of the Technical Section in terms of support and surveillance activities. The beneficial results of this effort are starting to show in several areas. An example is the establishment of a comprehensive thermodynamics program which gives better assurance of compliance with licence power limits. AECB staff is of the view that with continued effort, 1991 should show substantial gains compared to 1990.

3.1.10 Station Management

AECB staff approved two acting management appointments to accommodate the assignment of the station manager to the Organizing for Ownership Design Team. The temporary assignments became effective November 28, 1990, for a six-month term.

During 1990, the number of infractions of the operating licences and the AEC Regulations decreased compared to 1989 (see Figure 1). Station management

has continued efforts to improve compliance as discussed under Section 3.1.1. AECB staff is of the opinion that the 1990 level of infractions is still too high and that continued diligence by station management in this area is necessary to reduce infractions to an acceptable level.

There was evidence throughout the year that management was unable to sustain control of work standards and expectations. For example, during 1990, the station experienced a large number of lost-time accidents, excessive maintenance rework, unacceptably low levels of "wrench time", high numbers of outstanding preventative maintenance activities and chemistry control performance below standard. In an effort to overcome these shortcomings, significant effort was expended by management during the year on Ontario Hydro's In-Service Nuclear Station Quality Improvement Program (QIP). Attention was directed toward the establishment of an appropriate infrastructure for addressing the objectives of the QIP. A cooperative working relationship has been engendered with the union and professional employees which AECB staff believes is necessary for the program to be successful. Overall, the QIP had limited impact on station improvement during 1990. However, results are expected to become evident in 1991 as a number of the planned initiatives begin to take effect.

During 1990, station management responded to events of reactor safety significance in an appropriate manner with one exception, the Unit 2 flux tilt event described in Section 4.2.3. AECB staff concluded that station management should have been more aware of the situation as it was developing on Unit 2, and should have required the reactor to be shut down sooner. Since the occurrence of this event in September, 1990, station management has demonstrated a closer monitoring of and a more cautious approach toward reactor operation by taking action more promptly to correct safety-related faults arising during operation. AECB staff is pleased to see this improvement in safety culture and believes it is necessary to support a number of key QIP initiatives.

3.1.11 Housekeeping

Housekeeping continued to be a major deficiency in 1990. Although there have been improvements in the heavy water clean-up area, and station efforts to reduce the number of heavy water and waste oil drums stored along corridors and walkways in the reactor auxiliary bays have been successful, equipment, material and debris from ongoing work programs, such as Unit 3 rehabilitation, have taken the place of these drums and used up even more of the plant floor space. Large areas, especially in the 254' elevation, have been converted to storage and laydown areas which considerably restrict free and safe movement of personnel and equipment. Signs to warn of radiation hazards have been found to be inadequate in these areas. Radiation fields of up to 100 $\mu\text{Sv/h}$ have been measured by AECB staff inspectors at the boundary of these storage areas.

Other station areas requiring improvement were also identified by AECB staff during plant inspections. The use of crude make-do handwritten industrial and radiation safety signs has continued to be standard plant practice. Identification of liquid containers which contain recovered tritiated heavy

water is often incomplete and at times non-existent. Fire extinguishers and fire hose cabinets are not inspected at the required frequency and some are not installed properly. Contamination meters are found missing or non-operational at some interzonal boundaries. Lost time accidents have been increasing. Twenty-seven lost time accidents occurred in 1990 compared to ten during the 1986-1989 period and compared to the station target of three per year.

The station has recognized that more facilities (such as storage space) are required before the housekeeping issue can be satisfactorily addressed. A station strategic site plan to address this and other matters has been prepared by the station and will be presented for Ontario Hydro executive approval in spring, 1991. AECB staff supports this initiative and believes that in the absence of the facilities proposed, it is unlikely that a satisfactory level of housekeeping throughout the station can be achieved.

The cleanup of Unit 3 early in 1991 in preparation for restart following its rehabilitation outage is a major advancement in demonstrating the expected standard for a Pickering NGS-A unit. AECB staff is pleased to see the initiative taken by Ontario Hydro on Unit 3 and believes such effort is necessary on all Pickering NGS-A units as a part of the overall effort to bring the station to an acceptable standard of housekeeping and material condition. Unit 3 still has areas which require further attention, and diligence is necessary to ensure the job gets done and the good condition achieved will be maintained.

AECB staff considers that the situation at the end of 1990 remained unacceptable. However, AECB staff believes that if all initiatives are followed through, significant improvement in housekeeping and material condition of the plant should occur. Unit 3 is an example of the good results that can arise from a concerted effort.

3.1.12 AECB Staff Inspections

In the last quarter of 1990, AECB staff started a system of documenting deficiency findings arising from routine compliance field inspections and bringing them directly to the attention of the responsible shift supervisor for action and response. Eleven such communications have been transmitted to shift supervisors in 1990. Station management response has been favourable and the attention accorded by the shift supervisors to these findings has been acceptable. The AECB project office plans to devote more of its resources to compliance field inspections in 1991.

3.1.13 Quality Improvement Program (QIP)

In March, 1990, the Nuclear Generation Division of Ontario Hydro embarked upon a Quality Improvement Program for in-service nuclear stations. This program was implemented as the tool to "achieve and sustain excellence in the operation, maintenance and support of Ontario Hydro nuclear generating stations through the involvement, commitment, and contributions of all personnel".

In support of this program, performance objectives had been developed and issued in November, 1989. However, these initial objectives were too broad in scope and were unable to predict future performance trends. They were replaced by a new set in October, 1990.

In the first quarter of 1990, a station Quality Improvement Advisory Committee, and five sub-tier committee teams were formed at Pickering NGS to review and propose changes in previously identified deficient areas.

Progress and results were observed to be slow, as the second quarter activities were primarily limited to defining the role and function of the Quality Improvement Advisory Committee, and toward obtaining the involvement of employee representatives on the various committees. Quality improvement teams were established in the areas of Health and Safety, Involvement, Nuclear Safety, Maintenance, Work Authorization, Pre-job Assessment, Work Delays and Procedural Compliance.

By the fall of the year, divisional teams began providing material to support local initiatives. However, Pickering NGS identified a number of issues and obstacles to introducing the results of the divisional team, and also felt that the working relationships and work frustrations within the station needed to be addressed first. The station did complete, however, a number of old and new initiatives which were underway, all consistent with or supportive to the overall objectives of the QIP.

3.1.14 Safeguards

Throughout 1990, Pickering NGS has complied with Condition A.A.16 of the operating licences (relative to ensuring the peaceful use of nuclear material) to the satisfaction of the AECS staff.

3.2 Pickering NGS-A

3.2.1 Process Systems

There were no serious process failures in 1990. One potentially serious process failure occurred during the year. The event is described in Section 4.2.3.

3.2.2 Chemistry

Chemical control performance is determined from a combination of process equipment performance, laboratory performance, and chemical control performance for systems, as measured by the percentage of sample results within specification.

Overall chemistry performance at Pickering NGS-A is essentially the same as the previous year, but continues to be below station target. Substandard results continue in the feedwater systems, the water treatment plant and the irradiated fuel bay. The poor performance of the feedwater systems is largely the result of air ingress through the Unit 2 turbine condensers. A program to locate and correct these points of leakage is progressing. Water

treatment performance has declined due to continued problems with silica breakthrough. This is to be corrected by using a more efficient type of resin accompanied by an ongoing rehabilitation of the water treatment plant. Chemistry performance of the irradiated fuel bay continues to be poor due to infrequent changing of ion exchange resin.

The laboratory performance index for 1990 (78%) declined compared to the 1989 level (83%) and a target of 85%. A major contributor was the extra workload resulting from the implementation of the provincial Municipal Industrial Strategy Abatement (MISA) program. Staffing is to be increased and facilities improved in 1991 in an effort to improve laboratory performance.

3.2.3 Performance of Special Safety Systems

There were nine events which resulted in actual past unavailability of the ECCS, containment system and the shutdown system (SDS) in 1990. These and other reportable events are described in Appendix C. The actual past and predicted future unavailabilities are summarized in Appendix A.

The process used for predicting future unavailability of the Special Safety Systems is, in the opinion of AECB staff, not rigorous enough. As a result, the accuracy of the prediction of future unavailability is uncertain. Nevertheless, the prediction does give some insight into the expectation of the trend for future unavailability.

Ontario Hydro is currently producing new models as part of the risk assessment for Pickering NGS-A. This work has taken longer than originally anticipated. Completion is expected in 1991. The Pickering NGS-B assessment is scheduled for later.

3.2.3.1 Shutdown System

There was one event which resulted in actual past unavailability of the shutdown system on one unit during 1990. An impairment of the Unit 2 neutron overpower (NOP) trip coverage occurred as a result of a severe flux tilt on September 27, 1990. This resulted in an actual past unavailability for the Unit 2 shutdown system of 0.86×10^{-3} yr/yr which meets the target unavailability of 3×10^{-3} yr/yr. This event is discussed further under Significant Event Report (SER) A-90-137 in Appendix C.

The 1990 predicted future unavailability for the worst case accident (large loss of coolant accident, or LOCA) decreased from 1.59×10^{-3} yr/yr, reported in 1989, to 0.27×10^{-3} yr/yr. The primary contributor to the decrease was a revision to the shutdown system reliability model allowing separation of the shutoff rod failure rates between new and old shutoff rods.

During 1990, Unit 3 remained in a defuelled guaranteed shutdown state with the shutdown system out of service.

3.2.3.2 Containment System

The Pickering NGS-A target unavailability for this system is 3×10^{-3} yr/yr. There were four events during 1990 which resulted in actual past unavailability of 340×10^{-3} yr/yr for each unit. These were:

- a) Failure of elastomeric expansion joint seals in the pressure relief duct (PRD) during a pressure test to confirm the adequacy of the as-found condition of the seals (Appendix C, SER A-90-55). This resulted in 330×10^{-3} yr/yr actual past unavailability. See Section 4.1.2.2 for further details.
- b) Failure of a vacuum building upper chamber pump to trip (Appendix C, SER A-90-185) resulting in 9.6×10^{-3} yr/yr actual past unavailability.
- c) Unavailability of all three containment instrumented pressure relief valves (IPRV) due to the incorrect installation of a vacuum manifold pressure control valve actuator (Appendix C, SER A-90-70) resulting in 1.4×10^{-3} yr/yr actual past unavailability.
- d) A breach of containment through an airlock (Appendix C, SER A-90-105) resulting in 1.5×10^{-3} yr/yr actual past unavailability.

Another event (Appendix C, SER A-90-163) remains under review at the end of 1990.

The containment system predicted future unavailability is 4.39×10^{-3} yr/yr. This is somewhat greater than the 3×10^{-3} yr/yr target unavailability.

The filtered air discharge system (FADS) contribution to the containment predicted future unavailability increased from 0.32×10^{-3} yr/yr in 1989 to 1.59×10^{-3} yr/yr in 1990. This was due to an oversight in the unavailability block model in which the test interval for the carbon filter efficiency test actually used in operation was once every six months instead of once per month credited in the design analysis. Ontario Hydro is proposing a number of changes to return the reliability of FADS to an acceptable value.

The majority of the 340×10^{-3} yr/yr actual past unavailability was due to the failure of the PRD expansion joint seals which are only tested to design pressure once every ten years. Prior to restart of the reactors following the vacuum building outage, Ontario Hydro replaced all the elastomeric seals with a polyester-rubber composite. AECB staff believes that the new seal material provides a reliable containment seal in the short-term. To ensure reliable performance in the long-term, AECB staff concluded that a design change was necessary. Ontario Hydro has initiated a study of design options for secondary sealing arrangements which is expected to be completed by mid-1991.

Other areas of containment performance also require improvement to return the predicted future containment unavailability to target, not only for Pickering NGS-A, but also for Pickering NGS-B which has a target

unavailability of 1×10^{-3} yr/yr. Discussions with Ontario Hydro on other improvements to be undertaken are continuing.

3.2.3.3 Emergency Core Cooling System (ECCS)

The ECCS exceeded its target unavailability of 3×10^{-3} yr/yr in Units 1 and 4. Unavailabilities for 1990 were as indicated below:

Reactor Unit	Actual Past Unavailability $\times 10^{-3}$
Unit 1	400
Unit 2	0
Unit 3	Shut down for rehabilitation
Unit 4	920

Major contributors (details described in Appendix C) to actual past unavailability were:

- a) Debris found on Units 1 (SER A-90-72) and 4 (SER A-90-73) potentially would have disabled more than one moderator pump during ECCS recovery operation, resulting in 400×10^{-3} yr/yr and 440×10^{-3} yr/yr actual past unavailability respectively.
- b) A negative pressure excursion in containment (-3Kpa(g)) due to the unexpected opening of a containment IPRV (SER A-90-100/B-90-136) would have made the Unit 1 ECCS boiler room high pressure sensing instrumentation ineffective for small LOCAs resulting in 0.06×10^{-3} yr/yr actual past unavailability. This event demonstrates a cross-link between the ECCS and containment.
- c) Both Unit 4 moderator room sump pumps were discovered seized (SER A-90-178) resulting in 830×10^{-3} yr/yr actual past unavailability of ECCS recovery operation. Ontario Hydro has initiated actions to change all the moderator room sump pump carbon steel impellers and bowl assemblies with stainless steel components to prevent buildup of corrosion between the rotating impeller and its casing, and replace the 3 HP motors with 5 HP motors to increase the pump starting torque.

The high actual past unavailability of the Units 1 and 4 ECCS indicate clearly that the system needs improvement in performance. With the modification to the moderator room sump pumps, which also contributed to the unsatisfactory Unit 1 unavailability in 1989, the system unavailability should improve.

It should be noted that the predicted future unavailability given in Appendix A comes from an Ontario Hydro reliability study of the ECCS documented in 1985. This value may not be accurate for 1990 as the report has not been updated since 1985. Ontario Hydro does not intend to update

this analysis in view of the new models being produced in support of the Pickering NGS-A risk assessment.

3.2.4 Reportable Significant Events

A list of events reported pursuant to the Pickering NGS-A operating licence is given in Appendix C.

3.2.5 Measures of Station Performance

As an indication of the quality of overall station operation, measures of the performance of Pickering NGS-A, as evaluated by AECB staff, are attached in Appendix A. The data contained in this appendix was taken from Ontario Hydro Technical Quarterly Reports and records.

3.3 Pickering NGS-B

3.3.1 Process Systems

There were no serious process system failures in 1990.

3.3.2 Chemistry

During 1990, overall Pickering NGS-B chemistry performance deteriorated below the overall 1989 level and further below the station target.

Ongoing system chemical control problems included ingress of air to the turbine condensers, difficulty in controlling the level of dissolved deuterium gas in the heat transport system, high irradiated fuel bay conductivity and lack of particulate measurement in the stator cooling water.

See Section 3.2.2 for observations on chemistry lab performance and AECB staff views.

3.3.3 Performance of Special Safety Systems

A complete list of 1990 events which caused unavailability of Special Safety Systems is included in Appendix C. The actual past and the predicted future unavailabilities are summarized in Appendix B. Specific aspects of Special Safety System performance are discussed in the following subsections.

3.3.3.1 Shutdown Systems (SDS1 and SDS2)

Except for SDS2 in Unit 7, the shutdown systems in all units met their unavailability target of 1×10^{-3} yr/yr in 1990.

For Unit 7, SDS2 regional overpower trip coverage was in a level 2 impaired state (see Table 1 at the end of the report) for 57.3 hours resulting in a calculated unavailability of 6.54×10^{-3} . This unavailability was due to

impairment of regional overpower trip detectors as reported in SER B-90-197 (Appendix C).

The predicted future unavailability for both shutdown systems is below the target unavailability.

3.3.3.2 Containment System

The containment unavailability for each unit in 1990 was 340×10^{-3} yr/yr compared to the target unavailability of 1×10^{-3} yr/yr. Of this, 9.6×10^{-3} yr/yr was due to an upper chamber pump failure (SER A-90-185), 1.4×10^{-3} yr/yr was due to IPRVs being impaired because of incorrect installation (SER A-90-70) and the remaining 330×10^{-3} yr/yr was due to PRD seal failures during a pressure test (SER A-90-55). These were unavailabilities of components of containment shared between both Pickering NGS-A and -B. Further details are given in Section 3.2.3.2 of this report.

The predicted future unavailability for the containment system is 4.35×10^{-3} yr/yr. This fails to meet the target of 1.0×10^{-3} yr/yr. See Section 3.2.3.2 for further discussion on this matter.

3.3.3.3 Emergency Core Cooling System (ECCS)

ECCS unavailability for each unit in 1990 was 0.06×10^{-3} yr/yr compared to the target unavailability of 1×10^{-3} yr/yr. This unavailability was due to a spurious opening of an IPRV which reduced the effectiveness of the boiler room high pressure conditioning signal (SER B-90-136, SER A-90-100).

The predicted future unavailability for the ECCS is 0.634×10^{-3} yr/yr. This is better than the target of 1.0×10^{-3} yr/yr.

3.3.4 Reportable Significant Events

A list of events reported pursuant to the Pickering NGS-B operating licence is given in Appendix C.

3.3.5 Measures of Station Performance

As an indication of the quality of overall station operation, measures of the performance of Pickering NGS-B, as evaluated by AECS staff, are attached in Appendix B. The data contained in this appendix were taken from Ontario Hydro reports and records.

4. SIGNIFICANT LICENSING MATTERS AND ACTIVITIES

4.1 Common to Pickering NGS-A and Pickering NGS-B

4.1.1 Emergency Response Capability

4.1.1.1 Emergency Radiation Protection Procedures

The 1990 station radiation emergency exercises demonstrated the need for further improvement in the procedures. In addition, a training manual to support the procedures remains outstanding. Ontario Hydro has indicated that both items are to be completed by the end of June, 1991.

4.1.1.2 Emergency Operating Procedures (EOPs)

Ontario Hydro has been collaborating with Hydro-Québec and the New Brunswick Electric Power Commission in a program to improve EOPs. Current procedures are based on identifying the event. A new procedure which is symptom-oriented has been designed to maintain selected critical safety parameters within certain operating ranges. The intent is to continue using the present procedures and to switch over to this new procedure when events cannot be correctly identified or the present procedures prove to be inadequate. This new procedure has been written for Pickering NGS-A and -B and is due to be issued by the middle of 1991. Ontario Hydro is also doing a systematic review of all the existing procedures. The intent is to follow the recommendations of the inter-utility EOP standard. This should produce more user-friendly versions, better documentation of technical basis and supporting rationales, and more systematic verification and validation. This review and the issuance of revised procedures is expected to be completed by the end of 1994.

4.1.1.3 Fire Fighting Capability

In response to one of the recommendations of AECB report INFO-0234, "The Accident at Chernobyl and Its Implications for the Safety of CANDU Reactors", Ontario Hydro submitted report RMEP-IR-08965-20 entitled "Assessment of Fire Fighting Capability of Ontario Hydro's Nuclear Generating Stations". This latter report made 15 recommendations, 12 of which were applicable to Pickering NGS. In response to these recommendations, Ontario Hydro issued an NGD policy entitled "Fire Prevention and Protection Program for NGS Facilities". Implementation of this policy is expected to be completed by the end of 1991. Ontario Hydro has also initiated a fire risk assessment study for each of its nuclear generating stations. The assessment for Pickering NGS began in October, 1990, and is expected to be completed by late 1991.

The implementation of the NGD policy, and any recommendations that might come out of the risk assessment, are intended to satisfy the recommendations of the RMEP-IR-08965-20 report. AECB staff will continue to monitor progress in this area and will review the impact that Ontario Hydro's current plans has on the capability of fighting fires at Pickering NGS. AECB staff, with the assistance of a fire protection consultant, intends to conduct a

detailed evaluation of a forthcoming fire exercise upon implementation of the NGD policy.

4.1.2 Vacuum Building and PRD Inspection Outage

The Pickering NGS operating licences require the inspection of internal structures and components within the vacuum building at least once during any period of ten years. In May, 1990, the vacuum building was removed from service to permit the second such inspection (previous inspection in 1980). All eight Pickering NGS units were shut down for the duration of the outage, a period of 24 days.

4.1.2.1 Vacuum Building

On the whole, the vacuum building structure and associated components were found in good condition. Protective sealants and coatings in the main volume floor and the emergency water storage tank, and all concrete joint sealant were replaced as some deterioration had occurred. The vacuum building wall to roof seal was replaced as a preventative maintenance measure. A number of minor deficiencies were identified and repaired.

"As-found" and "as-left" air leakage tests were performed on the main chamber and upper chambers. Leakage rates were within target for all tests. The "as-left" leakage for the main chamber was 75% of the target value and for the upper chambers 35% of target.

A dousing test under atmospheric test conditions was carried out successfully.

4.1.2.2 Pressure Relief Duct (PRD)

Overall, the concrete structure and components were found in good condition. Some local concrete spalling and surface corrosion of metal components were identified and repaired. All 23 contraction and circular joint elastomeric seals were replaced with a new seal material. This was a planned activity as there was evidence from research and testing that the existing material was weakening over time and was vulnerable to failure in some locations. In addition, the elastomeric components on all containment pressure relief valves were replaced.

During the pressure test of the PRD, the measured leakage rate in the "as-found" condition at 13.8 kPa(g) was 2.6% of the contained volume per hour, exceeding both the Pickering NGS-B safety analysis limit of 2% and the station operational target of 1%. Subsequently, at 23 kPa(g), well below the design pressure of 41.4 kPa(g), a major failure of a seal occurred, and the test had to be abandoned. Following replacement of the seals, a test was carried out successfully at full design pressure. A leakage rate of about 50% of the limit assumed in the safety analysis was measured.

4.1.3 Boiler Emergency Cooling System (BECS) Status

In August 1990, Ontario Hydro informed AECB staff that the BECS on all Pickering NGS-A and -B units could, when initiated, cause a severe waterhammer transient in the BECS/reheater drains piping systems. Thermalhydraulic and piping stress analysis demonstrated that the potential transient loading conditions could result in high bending stresses, particularly in the area of the piping nozzle connections at the boilers. The stresses were predicted to exceed the yield point of the piping material.

As an interim measure, to ensure piping stresses will remain at an acceptable level, the BECS minimum allowable tank pressure and water level have been lowered from 625 kPa(a) and 2.2m to 230 kPa(a) and 1.35m respectively. Ontario Hydro has shown that this capacity is adequate to remove reactor decay and heat transport pump heat for at least 15 minutes. This time is sufficient to allow for the introduction of shutdown cooling at elevated temperatures.

At year end, the BECS on all units continued to operate in this temporary state awaiting full redesign and implementation of a new system.

4.1.4 Environmental Qualification (EQ)

There were limited activities at Pickering NGS in this area during 1990. These were:

- As part of a corporate environmental qualification pilot project, Unit 4 shutdown system electrical and control components were "walked down" and the required data were obtained.
- On discovery of waterproofing deficiencies on the Unit 4 shutdown system and ECCS junction boxes, a root cause determination was initiated and corrective actions were recommended. Similar inspection and remedial actions were initiated also on Unit 8.
- The practice of using unsealed marr connectors and butt splices in the wiring of Unit 4 Special Safety Systems was found and a technical investigation was initiated.
- The impact of backfitting Darlington NGS EQ maintenance requirements to Pickering NGS was investigated by applying the requirements to a limited number of components. The results are being assessed.

4.1.5 Filtered Air Discharge System (FADS)

FADS is designed to allow filtered venting of the containment atmosphere following a LOCA. Over the years, Ontario Hydro has implemented a number of changes to enhance the reliability, testability and maintainability of the system, and to allow verification of filter effectiveness before initiating discharges to the environment. Final modifications, involving reconfiguration of the system to enable air to be drawn preferentially from the vacuum building main chamber rather than from the PRD, were installed and commissioned during the vacuum building outage in May, 1990. However, the final configuration could not be placed in service until operating procedures had been issued in the spring of 1991. This fulfills commitments made by Ontario Hydro to the Board, although it should be noted that the original committed completion date, acknowledged and accepted by the Board, was October, 1988.

4.1.6 Post-Accident Radiation Monitoring

An Ontario Hydro review in 1988 identified numerous shortcomings in station equipment and procedures for monitoring radioactive releases, and for controlling the spread of radioactive contamination within the plant, following an accident involving fuel failures. Ontario Hydro has undertaken to correct these shortcomings by December, 1991.

4.1.7 Steam Line Failures Outside Reactor Building

Steam and feedwater system failures in the powerhouse would result in harsh environmental conditions which could adversely affect reactor shutdown, containment and heat sink capabilities. In July, 1984, Ontario Hydro was asked to carry out reviews on Pickering NGS-A and -B. The major recommendations for Pickering NGS-A included structural reinforcement of the south wall of the powerhouse, emergency steam venting system in the powerhouse, improved protection for electrical equipment, and additional control room protection.

Upon review of the Pickering NGS-B design, Ontario Hydro identified the recommendations that apply, in whole or in part, to this station.

The Pickering NGS-A powerhouse environmental modifications, with one exception, are scheduled to be in-service by the end of 1991 for Units 1, 2 and 3. The tie-in of the water supply from Pickering NGS-B to serve as the long-term heat sink has been delayed pending redesign of the BECS piping (see Section 4.1.3). Unit 4 is scheduled to enter into a 19-month retube outage in August, 1991, and the modification for this unit will be completed during this outage.

The in-service date for the Pickering NGS-B modifications remains unchanged at July, 1993.

AECB staff considers that the progress of the powerhouse environmental protection modifications is acceptable. AECB staff will continue its review and audit of selected topics and will continue to monitor progress via

periodic meetings with Ontario Hydro.

4.2 Pickering NGS-A

4.2.1 Loss of Coolant Accident (LOCA) and Failure to Shut Down

Following the accident at Chernobyl in 1986, AECB staff conducted a study of the event to ascertain the implications for the safety of CANDU nuclear reactors. One of the recommendations of this study called for a re-examination of the safety of the Pickering NGS-A reactors for dual failures involving the failure to shut down. In response, Ontario Hydro submitted a re-analysis of the consequences of a large LOCA and failure to shut down. AECB staff review indicated a number of significant shortcomings in the analysis and AECB staff judged that the issue could not be resolved solely by further analytical effort. Ontario Hydro was advised to investigate design improvements to the existing shutdown capability and inform AECB staff of the results. In January, 1990, Ontario Hydro submitted a formal proposal for enhancing the shutdown capability. The option chosen provides two shutdown systems which are not fully independent and which do not give two shutdown system coverage for a large LOCA. Nevertheless, Ontario Hydro considers this proposal is acceptable largely on the grounds that to install a fully independent second shutdown system capable of protecting against a large LOCA would be prohibitively complex and expensive, and that the reliability improvements to the existing capability ensure an acceptable risk to the public by reducing the probability of the most likely dual failures: loss of regulation plus failure to shut down, or small LOCAs plus failure to shut down.

AECB staff reviewed Ontario Hydro's submission and found that the investigation into potential alternatives was not as rigorous as expected. In response to a request by AECB staff, Ontario Hydro submitted additional information on three of the rejected options. One of these, the vertical liquid injection shutdown system (vertical LISS) concept, was judged the only potential alternative for providing an independent shutdown system and which would likely give full shutdown system coverage for all design basis accidents. However, Ontario Hydro stated that a detailed engineering assessment to determine its feasibility would take well into 1991 to complete. Also, such a system would be at least double the cost of the current proposal. Ontario Hydro concluded that the proposal put forward in January was still the best option.

In view of the likely practicability of a vertical LISS which would be capable of providing an adequate defence against all dual failures, including those involving large break LOCAs, AECB staff requested Ontario Hydro to carry out the detailed engineering assessment to demonstrate its practicability. This assessment is expected to be completed in October, 1991. At a progress meeting held in early February, 1991, Ontario Hydro informed the AECB staff that no obstacles had been identified to date which would prove the option impractical.

4.2.2 Rupture Panel System (RPS)

In March, 1987, the Board instructed Ontario Hydro to install pressure relief panels in all Pickering NGS-A units by the end of 1990. In conjunction with other modifications to the containment system, this would increase the repressurization time and reduce the containment venting rate following a postulated LOCA in any one of the units.

The new RPS was installed in Units 2 and 4 in 1988 and 1989, respectively. Installation in Unit 3 began in 1990 while the unit was out of service for rehabilitation and retube. The RPS was made available for service in Unit 3 prior to first criticality in May, 1991. Installation in Unit 1, with the approval of the Board, was postponed to March, 1991.

4.2.3 Unit 2 Flux Tilt Event

On September 27, 1990, Unit 2 was shut down manually because of a severe flux tilt in the reactor core. The flux tilt was the result of a xenon flux oscillation induced two days earlier by the reinsertion of adjuster rod AA14 into the core.

Following the recent conversion of the Pickering NGS-A core design from an 11-shutoff-rod, 18-adjuster-rod core to a 21-shutoff-rod, 8-adjuster-rod core, it became apparent that the significantly larger reactivity worth of each of the new adjusters, in particular peripheral adjusters AA5 and AA14, would result in high flux distortions if withdrawn or inserted singly. Flux control was not always possible due to the limited reactivity worth of the zone control system. Operating procedures were instituted to minimize such distortions.

The event began on September 25, 1990, with the reinsertion of AA14 into the core. This induced a xenon flux oscillation during which reactor power had to be lowered manually on several occasions to maintain reactor protective trip margins. Just prior to the decision to shut down the reactor manually on September 27, 1990, the power had been lowered to 56% of full power.

Analysis by Ontario Hydro determined that operation with both adjuster rods AA5 and AA14 fully out of the core would prevent similar oscillations of such magnitude from recurring. Ontario Hydro proposed continued operation on the basis that these adjusters would be locked out of the core in all Pickering NGS-A units, and that reactor power would be restricted to 90% of full power to ensure there would be no violation of licensed power limits. On this basis, AECB staff approved restart of Unit 2. In addition, AECB staff has prohibited operation of the Pickering NGS-A units with an unstable flux distribution, and has required Ontario Hydro to implement procedures to shut down immediately any unit encountering a flux instability.

Detailed investigations into this event were done by both Ontario Hydro and AECB staff. Root causes included, inter alia, inadequate procedures, inadequate training and ineffective feedback of operating experience.

4.2.4 Calandria Vault Corrosion

Last year AECB staff reported that inspections of Units 2 and 4 calandria vaults had revealed extensive corrosion of carbon steel components, such as the support beams and tie rods for the ion chambers, the brackets holding the ring thermal shield segments, the biological shield cooling system, and the dump tank legs. On the basis of visual examinations, it was believed that all components were still fully functional. The main concern was with continuing corrosion which could eventually lead to structural failure.

Ontario Hydro has determined that the corrosion is due to the effect of nitric acid thought to be formed by atmospheric nitrogen combining with airborne moisture in the presence of high radiation fields within the vault. The moisture can come from leaks in the piping located inside the calandria vault, or from spills in the boiler room, since the calandria vault is not sealed.

Ontario Hydro's action plans include the installation of vault drying systems in each of the four units in 1991, and installation of vault corrosion monitoring equipment in Unit 1 in 1991. Additional ion chamber supports have been installed in Units 2, 3 and 4, and will be installed in Unit 1 in 1991.

4.3 Pickering NGS-B

4.3.1 Mercury-Wetted Relays

Excessive failures of mercury-wetted relays (MWR) have occurred in the Special Safety Systems at Pickering NGS-B and other reactors. In 1989, Ontario Hydro initiated a project to replace existing MWRs with a new tin-doped version which is believed to be more reliable. Currently, all the SDS1 clutch coil MWRs have been replaced and SDS2 critical component MWRs have been replaced. The SDS1 main trip logic MWRs are expected to be replaced by mid-April, 1991. These were not replaced earlier because they had not been a problem. Other MWRs will be replaced as failures occur.

Ontario Hydro has also implemented a program to find an acceptable replacement dry-contact relay. Five potential candidates have been selected. A firm strategy for determining the replacement relay is expected by the end of 1991.

Table 2 at the end of this report summarizes the experience with unsafe failures of MWRs in the four Special Safety Systems. The results show the 1990 performance to be an improvement over that for the previous two years.

Late in 1990 the first failure of a tin-doped MWR occurred. No additional failures have been observed to date.

4.3.2 Moderator Low Level Trip

This additional reactor trip parameter on SDS1 and SDS2 was committed by Ontario Hydro to provide additional reactor protection for loss-of-moderator events. The scope and schedule for this backfit is being prepared to support "request for approval of funding" expected early in 1991. Since a two-year engineering and procurement cycle is estimated, installation is targeted for 1994/1995.

5. CONCLUSION

Last year AECB staff concluded that station operation must be improved. This conclusion remains unchanged as it is the assessment of AECB staff that although improvements were observed in some areas, overall station operation in 1990 did not change significantly compared to 1989.

Station performance in the following areas, which AECB staff considers require improvement, decreased or remained essentially unchanged relative to 1989:

- Availability of the containment system and the Pickering NGS-A ECCS (see Sections 3.2.3.2, 3.2.3.3 and 3.3.3.2).
- Worker safety - a dramatic increase in lost time accidents occurred in 1990 (see Section 3.1.11).
- Station maintenance (see Section 3.1.9.1).
- Surveillance of systems by the Technical Section (see Section 3.1.9.2).
- Housekeeping and plant material condition (see Section 3.1.11).
- Station chemistry (see Sections 3.2.2 and 3.3.2).
- Refresher training for control room operators and shift supervisors (see Section 3.1.6).
- Fire fighting capability (see Section 4.1.1.3).

Areas where improvements in station operation have been observed are:

- Reduction of the station internal dose arising from tritium uptake (see Section 3.1.3).
- Locations where housekeeping and plant material condition have improved (see Section 3.1.11).
- Unit 3 rehabilitation - good management and control of work resulting in a number of significant accomplishments (see Section 2).

- Establishment of a comprehensive thermodynamics trending program (see Section 3.1.9.2).
- Fuel handling capability (see Section 3.1.9.1)

1990 also saw extensive effort by station management toward the establishment of an appropriate infrastructure for addressing the objectives of the QIP. The QIP, together with other commitments by Ontario Hydro, address all areas identified above as requiring improvement. AECB staff was disappointed in the limited improvement achieved during 1990, but results are expected to become evident in 1991 as a number of planned initiatives begin to take effect.

TABLE 1

Ontario Hydro Definitions of Some Fault Types and Levels of Impairment

Process System Faults

- Type A: A fault which would, in the absence of special safety system action, cause significant fuel failures.
- Type B: A fault which would not, in the absence of special safety system action, cause significant fuel failures, but which would do so if some unpredictable factors were different, such as,
- i) reactor conditions being different, or
 - ii) the occurrence of a common mode fault which could have failed all redundant components of a system.

Safety System Faults

- Type 0: A fault which totally incapacitates the system such that it cannot provide any protection under any conditions.
- Type 1: A fault which significantly reduces system effectiveness such that it would be of little or no benefit if the worse possible process system failure occurred.
- Type 2: A fault which reduces the effectiveness of the system such that it fails to meet the design intent. However, the system still operates, and would be of significant benefit if a process system failure occurred.

Special Safety System Levels of Impairment

- Level 1: The system is ineffective to the degree that, given the worst process upset with which it is intended to cope, it would not provide adequate protection.
- Level 2: The system is reduced in effectiveness to the degree that, given the worst process upset with which it is intended to cope, it would provide some but not complete protection. However, the system does provide adequate protection for less severe process upsets.

Although each of the aforementioned faults and impairments are required to be formally reported to the AECB, these are not the only events requiring formal notification under the terms of the operating licences.

TABLE 2

Failures of Mercury-Wetted Relays in Pickering NGS-B Special Safety Systems

	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>Total</u>
SDS1	1	0	0	0	0	7	3	1	12
SDS2	0	0	0	0	2	8	12	0	22
Containment	2	2	1	2	11	5	5	3	31
ECCS	0	1	0	0	0	0	0	0	1
Totals	3	3	1	2	13	20	20	4	66

APPENDIX A

MEASURES OF STATION PERFORMANCE - PICKERING NGS-A, 1990

A. RADIATION CONTROL

Occupational dose*

	1990	1989	AECB Comments
Total whole body dose (person - Sv)	7.88	7.49	A
Total extremity dose (person - Sv)	23.96	16.37	A
Total neutron dose (person - Sv)	0.047	0.04	A
No. of exposures > regulatory limits	0	3	A
No. of whole body exposures > 20 mSv	46	6	A
			NI
<u>Releases from the Station</u>			
No. of times the 1% DEL target was exceeded (whly basis):			
Airborne tritium	0	1	A
Airborne noble gases	1	0	A
Airborne iodine-131	0	0	A
Airborne particulates	0	0	A
Airborne carbon-14	0	0	A
Waterborne tritium	0	0	A
Waterborne gross beta activity	0	0	A
<u>Average IDEL for the year:</u>			
Airborne tritium	0.23	0.47	A
Airborne noble gases	0.37	0.33	A
Airborne iodine-131	0.01	0.03	A
Airborne particulates	<0.01	0.01	A
Airborne carbon-14	0.11	0.17	A
Waterborne tritium	0.06	0.10	A
Waterborne gross beta activity	0.15	0.14	A

* Doses for those working on both stations are reported under Pickering "A"

A - Acceptable, NI - Needs Improvement, NA - Not Available

MEASURES OF STATION PERFORMANCE - PICKERING NGS-A, 1990

A-2

A. RADIATION CONTROL (Cont'd)		1990	1989	AECB Comments
<u>Public dose</u> (Pickering 'A' and Pickering 'B')				
Estimated dose to critical group (uSv):				
infant		44.5	43.5	A
adult		35.3	34.7	A
Estimated population dose (person · Sv)				
		1.45	2.1	A
<u>Environmental Measurements</u> (Pickering 'A' and 'B')				
Average boundary dose rate external gamma (mGy/hour)				
		43.9	42	
Average boundary tritium in air (Bq/m3)				
		17	22	A This represents 0.13 Maximum Permissible Concentration (MPC) for tritium in air for the public.
Average boundary tritium concentration in precipitation (Bq/L)				
		1330	2060	A This represents 0.61 MPCw for tritium in public drinking water.
Average boundary gross beta in precipitation and dry deposition (Bq/m2/month) (average of all measurement sites)				
		24.5	21	
Average tritium in milk (Bq/L)				
		65	54	A This represents 0.031 MPC for tritium in milk.
Average C-14 in milk (Bq/kg of carbon)				
		442	445	A This represents 0.451 MPC for carbon in milk.
Average I-131 in milk (Bq/L)				
		0.15	<0.16	A This represents 11 MPC for iodine in milk.
Average tritium in drinking water (Bq/L)				
		19	23	A This represents 0.01 x MPC for tritium in public drinking water.
Average gross beta in drinking water (Bq/L)				
		0.14	0.13	

MEASURES OF STATION PERFORMANCE - PICKERING NGS-A, 1990

B. PLANT CONTROL

	1990	1989	AECB Comments
No. of reportable events	26	33	NI
No. of reportable events where human error was a significant contributing factor	14	16	NI
No. of serious process failures	0	0	A
No. of reactor trips	5	3	--
Percentage of safety system tests completed:			
Shutdown system (SDS)	<100%	100%	NI Test (S90, EAF) not completed on Unit 4
ECCS	<100%	100%	NI A number of ECCS tests (E2, E3, E5, E6, E7) exceeded recall times on Unit 1
Containment	100%	100%	A
Forced Outages			
Unit 1	1	3	
Unit 2	3	1	
Unit 3 (In rehabilitation outage during 1990)	-	2	
Unit 4	0	3	

MEASURES OF STATION PERFORMANCE - PICKERING NGS-A, 1990Special safety system unavailability ($\times 10^{-3}$):Actual past unavailability:

	1990	1989	AECB Comments
SDS			
Unit 1	0	0	A
Unit 2	0.86	0	A
Unit 3	0	0	A
Unit 4	0	0	A
Containment			
Unit 1	340	2.32	NI
Unit 2	340	2.32	NI
Unit 3	340	2.32	NI
Unit 4	340	2.32	NI
ECCS			
Unit 1	400	1000	NI
Unit 2	0	182.9	A
Unit 3	N/A	0	Reactor core defuelled for retube.
Unit 4	920	0.42	NI
Predicted future unavailability:			
SDS			
Unit 1	0.27	1.59	A
Unit 2	0.27	1.59	A
Unit 3	0.27	1.59	A
Unit 4	0.27	1.59	A
Containment (each unit)			
Unit 1	4.39	3.07	NI
ECCS			
Unit 1	3.5	3.5	NI
Unit 2	3.5	3.5	NI
Unit 3	3.5	3.5	NI
Unit 4	3.5	3.5	NI

MEASURES OF STATION PERFORMANCE - PICKERING NGS-A, 1990

C. PLANT MAINTENANCE AND ADMINISTRATION		1990	1989	AECS Comments
<u>Documentation</u>				
Operating Memos (for Units 1-4):				
No. in effect at year end		106	93	NI
No. in effect for > 6 months		32	21	NI
Jumper Records (for Units 1-4):				
No. of operational jumpers in effect (at year end)		385	510	NI
Call-ups (outstanding at year end - for Units 1-4):				
Special Safety Systems		76	39	NI
Safety Support Systems		142	124	NI
No. of Deficiency Reports (at year end for Units 1-4):				
Special Safety Systems		744	-	NI Note: 1989 figures were omitted due to
Safety Related Support Systems		2710	-	NI lack of consistency with 1990 and
				the inability to confirm their source
D. LICENSING				
AECS Action Items:				
No. of Items outstanding at year end		54	48	NI
Quality Assurance Audits:				
No. of AECS audits		0	1	
Results of Audits:				
No. of Directives issued		0	1	-
No. of Action Notices issued		0	3	-
Health Physics (HP) Appraisals:				
No. of AECS HP Appraisals during year		0	1	
Results of Appraisals:				
No. of Recommendations		0	13	-
E. OPERATION				
Chemical control				NI
Housekeeping				NI
Radiation control				NI
Quality Assurance Program				--

APPENDIX B

MEASURES OF STATION PERFORMANCE - PICKERING NGS-B, 1990

A. RADIATION CONTROL

Occupational dose*

	1990	1989	AECB Comments
Total whole body dose (person · Sv)	1.13	1.40	A
Total extremity dose (person · Sv)	2.00	2.04	A
Total neutron dose (person · Sv)	0.01	0.008	A
No. of exposures > regulatory limits	0	0	A
No. of whole body exposures > 20 mSv	0	0	A

Releases from the Station

No. of times the 1% DEL target was exceeded (whly basis):

Airborne tritium	0	0	A
Airborne noble gases	0	0	A
Airborne iodine-131	0	0	A
Airborne particulates	0	0	A
Waterborne tritium	0	0	A
Waterborne gross beta activity	0	0	A

Average IDEL for the year:

Airborne tritium	0.10	0.10	A
Airborne noble gases	0.22	0.21	A
Airborne iodine-131	<0.01	0.032	A
Airborne particulates	<0.01	0.001	A
Waterborne tritium	<0.01	0.01	A
Waterborne gross beta activity	0.02	0.04	A

* Doses for those working on both stations are reported under Pickering 'A'

Public dose and environmental measurements are included under "MEASURES OF STATION PERFORMANCE PICKERING NGS-A, 1990" in Appendix A.

A - Acceptable, NI - Needs Improvement, NA - Not Available, UR - Under Review

MEASURES OF STATION PERFORMANCE - PICKERING NGS-B, 1989

B.

PLANT CONTROL

No. of reportable events
 No. of reportable events where human error
 was a significant contributing factor
 No. of serious process failures
 No. of reactor trips
 Percentage of safety system tests completed:
 SDS1
 SDS2
 ECCS
 Containment
 Forced Outages
 Unit 5
 Unit 6
 Unit 7
 Unit 8

	1990	1989	AECB Comments
	24	28	NI
	11	13	NI
	0	0	A
	8	5	-
	100%	100%	A
	100%	100%	A
	100%	<100%	A
	100%	100%	A
	0	2	
	1	1	
	0	1	
	2	2	

MEASURES OF STATION PERFORMANCE - PICKERING NGS-B, 1990

B-3

Special safety system unavailability ($\times 10^{-3}$):

Actual past unavailability:

		1990	1989	AECB comments
SDS1	Unit 5	0	0	A
	Unit 6	0	0	A
	Unit 7	0	0	A
	Unit 8	0	0	A
SDS2	Unit 5	0	0	A
	Unit 6	0	0	A
	Unit 7	6.5	0	NI
	Unit 8	0	17.32	A
Containment	Unit 5	340	2.3	NI
	Unit 6	340	2.3	NI
	Unit 7	340	2.3	NI
	Unit 8	340	2.3	NI
ECCS	Unit 5	0.06	0	A
	Unit 6	0.06	0	A
	Unit 7	0.06	0	A
	Unit 8	0.06	0	A
Predicted future unavailability:				
SDS1		0.485	1.87	A
SDS2		0.098	0.07	A
Containment		4.39	3.11	NI
ECCS		0.634	0.75	A

MEASURES OF STATION PERFORMANCE - PICKERING NGS-B, 1990

C. PLANT MAINTENANCE AND ADMINISTRATION

Documentation

Operating Memos (for Units 5-8):
 No. in effect at year end
 No. in effect for > 6 months

Jumper Records (for Units 5-8):

No. of operational jumpers in effect

Call-ups (outstanding at year end - for Units 5-8):

Special Safety Systems
 Standby Safety Support Systems

No. of Deficiency Reports (at year end - for Units 5-8):

Special Safety Systems
 Safety Related Support Systems

AECB Comments

1989

1990

NI

NI

NI

NI

NI

UR

UR

D. LICENSING

AECB Action Items:

No. of Items outstanding at year end

Quality Assurance Audits:

No. of AECB audits

Results of Audits

No. of Directives issued

No. of Action Notices issued

Health Physics (HP) Appraisals:

No. of AECB HP Appraisals during year

Results of Appraisals

No. of Recommendations

E. OPERATION

Chemical Control

Housekeeping

Radiation Control

Quality Assurance Program

50

1

1

3

0

0

NI

NI

NI

--

APPENDIX CREPORTABLE EVENTS

The following reportable events occurred in 1990:

1. Events Affecting Both Pickering NGS-A and -B

ReferenceDescription

SER A-90-10 On January 22, 1990, operators were performing routine contamination surveys of the administration building and found several "hot spots" with contamination up to 10,000 cpm on the carpeted area of the cafeteria. The contaminated carpet and tile on the 274' elevation near the main conference room were removed. One cleaning mop was found to have 700 cpm on it.

The radionuclides detected were Cs¹³⁷ and Co⁶⁰.

SER A-90-16 On January 31, 1990, radiation fields of approximately 3 R/h were found by a service maintainer when surveying a cardboard recycling bin east of the caged area by the water treatment plant. The source of the radiation was found to be discarded resin in the bin. The resin was removed and the bin was decontaminated.

SER A-90-55 On May 8, 1990, as a planned vacuum building outage activity, PRD was pressure tested. Expansion joint seal #44 failed at a pressure of approximately 23 kPa(g). The test was stopped and the joint seal was replaced. The design test pressure is 41.4 kPa(g).

A type 2 fault was declared and actual past unavailability of 7.6 years was assigned to this cycle-based failure event.

In Action Item 90-4-10 Ontario Hydro was requested to develop a more reliable, testable PRD seal.

SER A-90-70 On May 31, 1990, during a review of the alarm summary on Unit 2, the IPRV vacuum manifold pressure was found to alarm high. The fault was traced to incorrect reinstallation of the vacuum manifold pressure control valve (3422-MV49) actuator following maintenance performed during the vacuum building (VB) outage. When the malfunction was discovered, the VB had already been declared in service but all reactors were still shut down. The shift response was consistent with a level 1 impairment in which actions were immediately taken to replace the shutdown guarantee on Unit 6, which had already been surrendered (although not completely removed). The pressure control valve was repaired and was tested successfully.

SER A-90-84 On June 20, 1990, 28 dosimetry badges were placed in service, following a badge change, without thermoluminescent dosimeter (TLD) plaques installed. The omission was discovered and was corrected. It was noted that six of the affected badges had been worn by personnel; however, none of these persons were engaged in radioactive work.

Investigation shows that the root causes of the missing TLD plaques was due to lack of a formalized tracking system for badge loading. Major contributing factors include:

- i) less than adequate working environment,
- ii) unsorted badge racks,
- iii) less than adequate inspection of installed badge racks.

The investigation report includes six recommendations which will be taken to prevent recurrence.

SER A-90-100 On July 25, 1990, a negative pressure excursion occurred
SER B-90-136 in the Unit 1 and Units 5-8 boiler rooms due to the spurious opening of IPRV 1 during a routine logic test. The boiler room pressures decreased to approximately -3.5 kPa(g) from a nominal -0.5 kPa(g). This decrease in pressure would have made the ECCS boiler room high pressure conditioning function ineffective for small break LOCAs. The duration for this type 2 fault was 30 minutes.

SER A-90-163 On July 27, 1990 following the testing of a spare IPRV, it was found that the pressure controllers associated with the IPRVs are set to operate in a proportional control mode while the design computer codes used in the safety analysis assume that the IPRVs operate in a fully open to fully closed mode. The consequence of this discrepancy is that the station radioactivity releases resulting from certain design basis events may be different from those listed in the safety report. The controller gain settings were increased and set points lowered for the desired post-LOCA operation. Due to problems increasing the gains on the Pickering NGS-A controllers, IPRV control was temporarily transferred to the Pickering NGS-B Unit 5 unit emergency control center (UECC). A reassessment of the post-LOCA releases remained under review at year-end.

SER A-90-117 On August 23, 1990, as part of the powerhouse environment main steam line pipe restraint project, work authorization (WA) was requested by a construction foreman to relocate two high pressure ECCS trace heating electrical panels. Prior to approval of the WA, the rehabilitation shift supervisor found that construction workers had already removed the heat tracing panel, 0-63335-PL1723. There was no known

interruption of the high pressure ECCS trace heating system during the period in question. Nevertheless, the event was a violation of OP&P 01.6(c) such that a temporary change to a special safety system was implemented without the prior approval of the shift supervisor.

SER A-90-174 As a follow-up to the vacuum building dousing test, analysis indicated that for limiting accidents like a large LOCA, backflow of contaminated water through the upper chamber seal water tanks liquid drains 7133-Y503 and Y510, may start accumulating in the vacuum building basement within 15 minutes. If not isolated prior to this time, the presence of the water could impede subsequent operator access to the vacuum building basement to isolate this leakpath from containment.

Immediate action was taken to temporarily reconfigure the upper chamber pump seal water supply and eliminate the need for post-LOCA isolation. Further design changes may be desirable to optimize the normal operation of this system and Ontario Hydro is proceeding to identify what permanent changes, if any, are appropriate.

SER A-90-181 During phase B commissioning at Darlington NGS, it was discovered that the Darlington reactors had been inadvertently fuelled with depleted bundles of both 0.4% and 0.5% U-235. The planned loading of depleted fuel was to be all 0.4% U-235.

Investigation at Pickering NGS revealed that:

i) Two bundles in Unit 1 channel K18E positions 5 and 6 were loaded with 0.4% U-235. At the time of refuelling, these two bundles were thought to be 0.5% U-235 and were modelled as such in SORO. This error has been corrected and was found to be insignificant from a safety point of view.

ii) Following retubing, Unit 2 was inadvertently loaded with 0.4% U-235 depleted bundles in 1988, whereas the analyzed and simulated loadings assumed 0.5%. Resimulation of operating history with the fuel correctly modelled confirmed that licence limits on bundle and channel power were not exceeded, and NOP effectiveness was not impaired. Unit 2 no longer contains depleted fuel.

Ontario Hydro is taking action to ensure that the loading of depleted fuel into Pickering NGS units will be done correctly in future.

Fourth Quarter
Technical Report

The FADS contribution to the containment predicted future unavailability (1.59×10^{-3} yr/yr) increased substantially over the 1989 value (0.32×10^{-3} yr/yr). This was due to an oversight in the unavailability block model which credits the high efficiency carbon absorber (HECA) filter efficiency test interval as monthly. The filter efficiency is actually measured once every six months.

Letter, Grandame
to Dewar,
1990 10 03

OH was informed that the use of students as the only guard in the security monitoring room is a violation of the Physical Security Regulations.

2. Events Affecting Pickering NGS-A Only

Reference

Description

Letter, Schuelke
to Schwarz
1990 02 01

On January 5, 1990, during an inspection on Unit 3, a recordable indication was found on main steam line (MSL) #14 by radiographic examination at target weld location #9.

Further analysis determined the indication to be a sub-surface slag-type inclusion (ie, a manufacturing defect) with no sign of the inclusion propagating during its service life. Therefore, no repair was done. AECB staff had accepted Ontario Hydro's proposal to reinspect MSL #14 at target weld location #9 during the next major planned outage of Unit 3, and requested that the indication continue to be reinspected at five year intervals to confirm its stability.

SER A-90-45

On April 12, 1990, construction personnel inadvertently carried out commissioning tests using a flask containing four irradiated end fitting stubs. This resulted in the transfer of two radioactive stubs into the dry storage module. An empty flask should have been used for the commissioning operation. There is no evidence that any significant radiation doses were received by the workers.

SER A-90-46

On April 11, 1990, during retubing activities, the Unit 3 fuelling machine bridge with a shield cabinet installed, was moved downward from row H to row J. Suddenly, an unrequested downward tilt motion of the south side of the bridge was noticed by the workers inside the shield cabinet. The total travel of that side of the bridge was approximately 33 inches. There was no injury to workers.

Subsequent investigations by Ontario Hydro (D&D Report No. 90477) concluded that "the present bridge drive design is not safe and efforts to remedy this situation should begin immediately" and a "number of modifications to make the Pickering NGS bridges acceptably safe are recommended".

AECB staff had requested Ontario Hydro to indicate what recommendations were accepted, what work has been done and the schedule for completing outstanding work.

SER A-90-51

During a shutdown on April 27, 1990, it was noticed that Unit 4 BECS injection valves, 3671-MV2 and 3672-MV14, did not open automatically as designed. It was found that the valves' manual handwheel mechanisms were placed in a position which would not allow automatic operation if BECS was required. The valves were returned to the normal operating state and the function was successfully tested. This type of valve is used only at Pickering NGS-A. A level 1 impairment was declared.

SER A-90-69

On May 23, 1990, a mechanical maintainer received an extremity dose of 32.4 rem to his right hand and 420 mrem to his left hand. The maintainer received the exposure while working in the mechanical maintenance decontamination shop on part of a valve from the Unit 1 heat transport feed and bleed circuit. The high exposure to the right hand is thought to have been caused by a combination of brief contact with the valve gate, which had contact dose rates of 450-500 mrem/h gamma and 150 rads/h beta, plus a contamination buildup on the mechanic's gloves. The regulatory limit at the time of exposure was 38 rems per quarter of a year and 75 rems per year. An operating memo has been written specifying actions to prevent further similar incidents.

SER A-90-72

On May 26, 1990, during modification of the Unit 1 east side fuelling machine ECCS recovery screen, a 4' x 6' burlap blanket was found in the internal sump pathway for D₂O. The blanket was removed and disposed of. This was classified as a type 2 fault with duration of 146 days.

SER A-90-73

On May 27, 1990, video inspection found some debris in the Unit 1 east side ECCS pipe work. The debris was removed. This was classified as a type 2 fault with duration of 146 days.

On June 9, 1990, video inspections of the ECCS recovery piping revealed various pieces of debris in Unit 4. The event was classified as a type 2 fault with a duration of 160 days. No SER was produced nor was written notification formally issued to the AECB.

SER A-90-82

On June 15, 1990, a service maintainer discovered that high gamma fields near Unit 3 airlock 3 were due to a radioactive waste bin. Contact dose rates on a bag of waste in that bin were found to be about 50 R/hr. The bag was subsequently removed to an approved storage area.

Since there was no posted signs warning of the radiation field in the vicinity of the airlock in excess of 2.5 mrem/h, nor was a conspicuous sign posted on the bag warning of a high local radiation field, and since an atomic radiation worker was not present and supervising the material, this event was a violation of the AEC Regulations, Section 22.

SER A-90-91

On July 3, 1990, Unit 1 was ready to be restarted after a maintenance outage to perform repairs on the heat transport system shutdown cooling system. The heat transport system had been cooled down and depressurized on July 1, 1990, without being in a guaranteed shutdown state. This was in conflict with Operating Memo 90-182 in effect at the time.

This resulted in a trip coverage impairment for the duration of the shutdown. The duration of the fault was approximately 54 hours.

Letter, Dewar to
Schwarz,
1990 07 16

During the inspection program on the Unit 3 MSLs, recordable indications were found at the following locations by radiographic examination:

<u>Loc #</u>	<u>MSL#</u>	<u>Date Inspected</u>
7	12	July 8, 1990
10	12	July 15, 1990
12	16	July 15, 1990

Further investigation revealed that Loc #10 MSL #12 was found to be acceptable as the indication was only a grind mark, Loc #12 MSL #16 was also judged to be acceptable but will be reinspected every five years. The porosity found at Loc #7 MSL #12 was repaired. In addition to the above, a new recordable indication was found at Loc #13, MSL #12 and is still under investigation.

SER A-90-105

On August 7, 1990, a mechanical maintainer proceeded through Unit 4 airlock 5 using an unapproved procedure. This resulted in a breach of containment, with the inner door seals of the airlock deflated and the outer door simultaneously open.

A type 2 fault of the containment system, with a duration of eight minutes, was declared.

SER A-90-137

On September 25, 1980, when adjuster rod AA14 was inserted into the Unit 2 reactor core, a depression of the neutron flux in that area led to a significant flux tilt. The resulting xenon transient caused a flux oscillation with a period of approximately 26 hours. A number of fuelling operations were completed in an attempt to dampen the oscillation but were unsuccessful, and the unit was shutdown on September 27, 1990, after approximately two periods of flux oscillation.

SER A-90-166

On November 10, 1990, the circuit breakers for Unit 1 liquid zone control system (LZCS) compressor 3481-CP2 and the Unit 2 pump 2-3481-P2 were found to be in the open position (these breakers are both located on the 274' elevation along the main reactor auxiliary bay corridor). Immediately after the breaker 'open' positions were noted, actions were taken to start the second LZCS compressor on Unit 1 and the standby pumps on Unit 2. The 'open' breakers were subsequently closed, and the systems were returned to their previous configuration.

Following this incident, all breaker positions were verified to be correct on Units 1 and 2, and all unit operators were instructed to maintain extra vigilance. A station investigation was held to determine the cause of the breaker openings and to determine an appropriate course of further investigation.

SER A-90-178

On December 1, 1990, Unit 4 moderator sump pumps were test run. Both sump pumps started, but tripped on overload within a few seconds. Both pumps were repaired and tested successfully. An investigation concluded that the cause of the failures was due to the corrosion of the cast iron impeller and pump bowl assembly.

A type 2 fault of the ECCS recovery system, with a duration of 302 days was declared. This problem has occurred previously on other units.

Ontario Hydro is in the process of replacing the carbon steel impellers and bowl assemblies with stainless steel components and replacing the 3 HP pump motors with 5 HP motors to increase the pump starting torque.

3. Events Affecting Pickering NGS-B Only

Reference

Description

- | | |
|---|--|
| SER B-90-13 | On January 20, 1990, Unit 7 had a reactor trip initiated by a loss of power to Class II bus 7-5424-BUD. This occurred during a non-routine test of the emergency Class II transfer scheme. When doing this test, the power supply to the BUD bus failed to transfer from the normal supply to the emergency transfer supply. This caused a loss of feedwater to two quadrants of boilers resulting in an SDS1 trip on high heat transport temperature and an SDS2 trip on low boiler level. The Class II transfer failed because a transfer lockout relay was erroneously in the energized state. The reason for it being energized could not be determined. A site engineering change has been issued to provide both a control room alarm and a local panel alarm when the lockout relay is energized. Since a transfer is done manually, this will allow for a quick reset if an erroneous lockout condition exists at the time a transfer is about to be done. |
| SER B-90-51 | On April 2, 1990, SDS1 in Unit 7 was impaired due to inadvertent shut-off rod operation. While troubleshooting a shutoff rod-ready indicator, an operator inadvertently drove, under manual control, a bank of rods partially into the core. The rods went no more than a few percent of full travel but that was enough to place SDS1 into a not armed state. The operator immediately set the control mode hand switch into auto mode and the rods automatically drove out of the core. Recovery was quick. This event was reported as a level 1 impairment and was later classified as a type 4 fault. |
| Letter,
Schuelke to
Schwarz
1990 04 30 | On April 30, 1990, Ontario Hydro reported that they could not assure that gravity driven poison ingress will provide a timely reactor shutdown for some intermediate size moderator pipe breaks at high reactor power levels. This discovery invalidates the basis for a conclusion, reported to the AECB, that a Pickering NGS-B moderator pipe break was not a serious process failure. However, due to the low probability of the initiating event and the mitigating design features provided by the SDS1 and SDS2 neutron over power trips, operating the reactor with the current plant design complies with AECB safety requirements. |

- SER B-90-102 On June 10, 1990, testing of the ECCS recovery system indicated the presence of a level 2 impairment of the system. The shift personnel took the appropriate action in response to the impairment. It was found subsequently that the test data had been misinterpreted and that no significant impairment was present. The event was classified as a type 4 fault.
- SER B-90-114 On June 24, 1990, cooling water was isolated to an ECCS recovery heat exchanger. This was done to repair a flow gauge instrument line which had broken off. The job was done using a non-standard procedure and AECB approval was not obtained. This was a violation of OP&P 00.2.4.
- SER B-90-123 On July 15, 1990, during routine testing on Unit 8, both
SER B-90-124 channel H and channel G failed to trip on SDS2 boiler feedline low pressure. Channel H failed due to a faulty relay which was replaced and when channel G was retested, it worked properly. This event was a type 1 failure of the trip parameter. However, Ontario Hydro classified this as a type 3 fault of SDS2 since, when backup trip parameters are considered, trip coverage was still provided for all design basis accidents.
- SER B-90-125 On July 18, 1990, ECCS injection system pump 058-3335-P7 was isolated for an oil change. This isolation was done without the required shift supervisor approval resulting in a violation of OP&P 00.2.3. When the error was revealed, further work and isolation was stopped until production manager approval was obtained. The incident was reviewed with the operator involved and follow-up reviews have also been done.
- SER B-90-131 On July 20, 1990, during routine testing of the ECCS recovery system, all four channel (K,L,M,S) recovery sump level transmitter reference lines were found to be capped in Unit 8. Blocked reference lines would not prevent the transmitters from detecting a sump level rise and initiating ECCS recovery. However, the blocked lines could cause premature initiation of the recovery system. The consequences of having the reference lines blocked are currently under investigation.
- Letter, Dewar On August 10, 1990, Ontario Hydro informed the AECB that
to Schwarz the SDS2 low core pressure drop trip may not be effective
1990 08 10 for a specific loss of electrical power event. In particular, for a loss of electrical power resulting in a primary heat transport pumping configuration of 2-1 in a loop, the current SDS2 setpoint of 450 kPa(d) may not generate a trip signal. Analysis however, showed that a setpoint of 460 kPa(d) would be adequate. The AECB has accepted an Ontario Hydro proposal to change the setpoint to 500 kPa(d).

- SER B-90-172 On September 23, 1990, low pressure service water check valve 6-7131-NV206 ruptured in Unit 6. This valve is on the line feeding the ECCS test heat exchanger and the ECCS pumphouse air conditioning units. The check valve has been sent to Ontario Hydro Research to determine the failure mechanism. Ontario Hydro plans to inspect similar valves in the other units. The results of these investigations will be documented in an SER follow-up report.
- SER B-90-197 On November 14, 1990, two regional overpower (ROP) measurements on each of channels G and H in Unit 7 were reading greater than 7% below the required detector setting (RDS). This was a level 2 impairment of the ROP trip parameter. The impairment was found during a routine AECS staff inspection. Following operating manual procedures, the production manager was notified and both channels were recalibrated.
- SER B-90-207 On December 6, 1990, Pickering NGS Health Physics Section was informed that a mechanical maintainer had incurred a tritium uptake of 448 uCi/l. The maintainer was immediately placed on removal. An investigation determined the most probable cause was moderator water contamination while working on Unit 5 moderator equipment and not wearing proper protective clothing. The maintainer was quickly placed on a dose reduction program. Actions based on an investigation will be included in a forthcoming SER follow-up report.

APPENDIX DVIOLATIONS OF LICENCES AND REGULATIONS1. Events Affecting Both Pickering NGS-A and -B

<u>Reference</u>	<u>Description</u>
SER A-90-10	On January 22, 1990, contamination up to 10,000 cpm was found in the administration building. This violated Section 5.1.3.2 of the Ontario Hydro Radiation Protection Regulations which are referenced in Licence Condition A.A.1.
SER A-90-16	On January 31, 1990, radioactive resin was found in a cardboard recycling bin located near the water treatment plant. This violated Section 22 (4) of the AEC Regulations.
SER A-90-70	On May 31, 1990, IPRV vacuum manifold pressure was found to be high due to an incorrectly reinstalled control valve. The installation took place following maintenance during the vacuum building outage. At the time the fault was discovered, the vacuum building had already been declared in service. This violated Section 03.1 (b) of the Pickering NGS-A OP&Ps.
SER A-90-84	On June 20, 1990, 28 dosimetry badges were placed into service without thermoluminescent dosimeter plaques installed. This violated Section 24 (1) (b) of the AEC Regulations.
SER A-90-117	On August 23, 1990, a temporary change to the ECCS was made prior to approval of the shift supervisor. This violated Section 01.6 (c) of the Pickering NGS-A OP&Ps.
Letter, Grandame to Dewar, October 3, 1990	Ontario Hydro was informed that the use of students as the sole guard in the security monitoring room was a violation of the Physical Security Regulations, Section 29.
SER A-90-82, and 4th Quarter Technical Report	These two references are violations of Licence Condition A.A.19. The event took place on June 15, 1990, and the reporting letter was not written until February 1, 1991. This violated the requirement to report promptly. The technical report showed previously reported information on FADS to be inaccurate. The knowledge of inaccurate information is a reportable event but a reporting letter was not sent. This violated the requirement to report.

2. Events Affecting Pickering NGS-A

- SER A-90-45 On April 11, 1990, construction personnel inadvertently used a flask containing irradiated end fitting stubs. Storing radioactive material in an inappropriately marked container violated Section 22 (1) of the AEC Regulations.
- SER A-90-51 On April 27, 1990, it was discovered that the Unit 4 BECS injection valves were not set in the automatic position. This violated Section 36.4 of the Pickering NGS-A OP&Ps.
- SER A-90-72 On May 26,27 and on June 15, 1990, ECCS recovery paths in
SER A-90-73 Pickering NGS-A were found blocked resulting in type 2 faults. This was a violation of Licence Condition A.A.11.
- SER A-90-82 On June 15, 1990, a radioactive waste bin containing contact dose rates about 50 R/h was found near a Unit 3 airlock. In the area, there were no posted signs to indicate fields in excess of 2.5 mrem/h. This violated Section 22 (4) of the AEC Regulations.
- SER A-90-105 On August 7, 1990, Unit 4 airlock 5 had a breach of containment due to a mechanical maintainer proceeding through the airlock using an unapproved procedure. This violated Section 21.1 of the Pickering NGS-A OP&Ps.

3. Events Affecting Pickering NGS B

- SER B-90-114 On June 24, 1990, repair to the ECCS was done using a non-standard procedure. AECB approval for this procedure was not obtained. This violated Section 002.4 of the Pickering NGS-B OP&Ps.
- SER B-90-125 On July 18, 1990, an ECCS pump was isolated for an oil change. The isolation was done without obtaining shift supervisor approval. This violated Section 002.3 of the Pickering NGS-B OP&Ps.